THE OPEN UNIVERSITY
S102: A SCIENCE FOUNDATION COURSE

SCIENCE

Introduction and Study Guide

SUP 26937 7

A SCIENCE FOUNDATION COURSE

INTRODUCTION AND STUDY GUIDE

THE SCIENCE FOUNDATION COURSE TEAM

Steve Best (Illustrator)
Geoff Brown (Earth Sciences)
Jim Burge (BBC)
Neil Chalmers (Biology)
Bob Cordell (Biology, General Editor)
Pauline Corfield (Assessment Group and Summer School Group)
Debbie Crouch (Designer)
Dee Edwards (Earth Sciences; S101 Evaluation)
Graham Farmelo (Chairman)
John Greenwood (Librarian)
Mike Gunton (BBC)
Charles Harding (Chemistry)
Robin Harding (Biology)
Nigel Harris (Earth Sciences, General Editor)
Linda Hodgkinson (Course Coordinator)
David Jackson (BBC)
David Johnson (Chemistry, General Editor)
Tony Jolly (BBC, Series Producer)
Ken Kirby (BBC)
Perry Morley (Editor)
Peter Morrod (Chemistry)
Pam Owen (Illustrator)
Rissa de la Paz (BBC)
Julia Powell (Editor)
David Roberts (Chemistry)
David Robinson (Biology)
Shelagh Ross (Physics, General Editor)
Dick Sharp (Editor)
Ted Smith (BBC)
Margaret Swithenby (Editor)
Nick Watson (BBC)
Dave Williams (Earth Sciences)
Geoff Yarwood (Earth Sciences)

Consultants: Keith Hodgkinson (Physics)
Judith Metcalfe (Biology)
Pat Murphy (Biology)
Irene Ridge (Biology)
Jonathan Silvertown (Biology)
External assessor: F. J. Vine FRS

Others whose S101 contribution has been of considerable value in the preparation of S102:
Stuart Freake (Physics)
Anna Furth (Biology)
Stephen Hurry (Biology)
Jane Nelson (Chemistry)
Mike Pentz (Chairman and General Editor, S101)
Irene Ridge (Biology)
Milo Shott (Physics)
Russell Stannard (Physics)
Steve Swithenby (Physics)
Peggy Varley (Biology)
Kiki Warr (Chemistry)
Chris Wilson (Earth Sciences)

The Open University, Walton Hall, Milton Keynes MK7 6AA

First published 1987. Reprinted 1988, 1989, 1991, 1992, 1993, 1994.

Edited, designed and typeset by the Open University

Printed and bound in the United Kingdom by Staples Printers Rochester Limited
Neptune Close, Medway City Estate, Frindsbury, Rochester, Kent ME2 4LT

Further information on Open University courses may be obtained from the Admissions Office, The Open University, P. O. Box 48, Walton Hall, Milton Keynes, MK7 6AB.

6.2

1 INTRODUCTION

Welcome to S102! We very much hope that you will enjoy the Course. Whether or not you have studied science before, there will be plenty of exciting and challenging material for you to study.

This Introduction and Study Guide will give you some idea of what the Course is about, and we hope it will help you to organize the Course material. You will also find some useful advice about how to go about studying and learning. It will provide you with information that will be useful throughout the year, and you should read it before starting the rest of the Course.

The booklet divides into two main parts. Sections 2 to 5 provide details about the Course content, components, items you need to provide and assessment. Sections 6 and 7 are to help you with your studying and learning and give you some ideas about what you can expect to achieve through your studies. You will find this Section useful to read throughout the Course, but it is particularly important to have to hand when you come to do assignments. On the back cover, there is useful reference material that you may need from time to time.

2 THE COURSE

S102 covers topics from four distinct but closely related scientific disciplines: physics, Earth sciences, chemistry and biology. The Course starts by looking at how scientists make detailed observations about our planet and Solar System, and ends by considering the very latest developments in particle physics. As you work through the Units, you will explore many aspects of science, which will enable you to understand a wide variety of phenomena within and on our Earth. During the Course, you will appreciate that each discipline approaches its problems and investigations differently, and this will give you an insight into more advanced study. You will also come to appreciate the temporary nature of our scientific knowledge, which is constantly being challenged and modified.

The Course makes use of several types of learning material: the text, practical work, television, and audiovisual sequences (tape sequences linked to a series of diagrams and descriptions within the text). These form part of your independent work at home. During Study Centre sessions and your week's Summer School you will work with other students and with tutors.

The Course Team is well aware that, for many students, studying S102 is a first encounter for some time with academic work. We have assumed that students have only an everyday knowledge of science and of the skills needed to learn about science. For example, you may know no mathematics beyond simple arithmetic, you may not be familiar with reading and understanding scientific writing, or you may not find it easy to put your ideas together in writing an account or explanation. As you progress through the Course, you will build up these (and other) skills, so by the end you will be able to do certain types of calculation, analyse and formulate written arguments, and write clear, well-structured answers to assignments. These are skills that will stand you in good stead during the remainder of your undergraduate career, whatever courses you choose to study. In addition to acquiring these skills, you will also know much more about scientific inquiry and thinking, and be able to explain phenomena that

you learn about. As a foundation course, S102 forms a basis for higher-level science courses, but it is also written for those who do not plan to study science further.

The breadth of scientific knowledge that you will derive from the Course will give you insights into many environmental and medical issues, as well as purely scientific ones, and former students have found it fascinating to relate this knowledge to aspects of everyday life. Your training in thinking about and understanding scientific issues will provide you with a structure that will be useful whatever you may be involved in. By the end of the Course you may well agree with Einstein's comment that 'the whole of science is nothing more than a refinement of everyday thinking'.

3 COURSE COMPONENTS

This Section describes the various components that are supplied and sent to you (Table 1). You will receive these components in *three* mailings despatched during the year.

TABLE 1 Course components

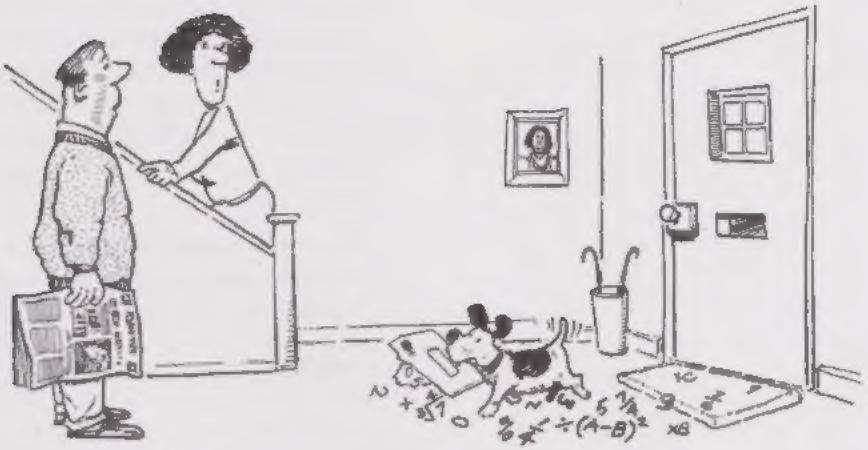
WE PROVIDE:		YOU PROVIDE:
Before you start:	During the Course:	
Into Science	text of Units 1–32	Notebook
	Course Index	TV
	Glossary	audiocassette player
	Study Calendar	calculator
	Assignment Booklets	extra items for experiments
	Experiment Kit	
	TV programmes	
	audio tapes	
	tutorials at Study Centre	
	Summer School	
	Revision Guide	
	Specimen Exam Paper	
	examination	

3.1 PREPARATORY MATERIAL

To help you to prepare for the Course, we provide you with *Into Science*. *Into Science* introduces you to studying using distance learning. Scientific ideas, and the processes that enable scientific work to develop, are considered as well as important study skills such as writing scientifically and using mathematics. As you study *Into Science* you will begin to apply maths skills to scientific processes and ideas, and come to appreciate the importance of these skills in science. By working through *Into Science* you will be better equipped to begin your study of S102.

As part of the preparatory material you can complete some assessment material to help you to assess your progress. There are also complementary TV programmes that relate to the maths work.

You will find it especially useful to study *Into Science* if it is some time since you have done any mathematics or you have not studied for some time.



'Looks like your *MAFS* package.'

3.2 THE COURSE UNITS

The Course consists of 32 Units, and each Unit normally takes a week of part-time study (see Section 6.2). The Units are grouped into discipline-based blocks, which we have colour coded: red for physics and general science; blue for Earth sciences; yellow for chemistry; and green for biology. The Units are divided among the disciplines as shown in Table 2.

TABLE 2 How the Units are divided between the four disciplines

Physics	Earth sciences	Chemistry	Biology
UNITS 1 to 4 general science and physics			
	UNITS 5 to 8 Earth sciences		
UNITS 9 and 10 physics			
		UNITS 11 to 18 chemistry	
			UNITS 19 to 26 biology
	UNITS 27 to 29 Earth sciences		
UNITS 30 to 32 physics			

The Course contains two unusual Units. Unit 4 introduces you to practical work in science and some of the skills you will need as you write up, analyse and interpret your experimental work. Although you should work through this Unit during the assigned study week, you should also regard it as reference material for use later in the Course. Unit 26, 'Biology reviewed', looks back at the biology Block, and provides extra questions, examples and summary material to help you consolidate your work on the biology Units.

The core of every Unit is the text and associated TV programme. Integrated with some texts are audiovisual (AV) sequences and experimental work (Table 3).

TABLE 3 Unit components

UNIT		
text	TV programme	all Units have these components
AV sequence	experimental work	a Unit may have these components
assignment (TMA; CMA)		most Units will be assessed as part of a TMA and/or CMA

THE TEXT

This part of the Unit is intended to be used as a workbook. You should always read the Study Guide at the beginning of each text, which will tell you about the content and the components involved. For instance, it will tell you whether the Unit contains experimental work, and (if so) roughly how long it should take.

The text is your main learning material and to help you work your way through it, there are two kinds of questions. In-text questions (ITQs) are set within the Sections and help you progress to the next step in the learning process. You should always do them when you come to them and then compare your answer with ours. In answering the question or solving the problem, you learn something new that you need to know before you continue, so don't be tempted to skip them! Some ITQs are numbered, others are not. Those that are not numbered are answered shortly after the question is posed, whereas the numbered ITQs are answered at the back of the text.

Self-assessment questions (SAQs) are to help you to judge how well you have understood the important concepts. You will normally find these at the end of a Section. It is a good idea to do these questions when you come to them, but you may prefer to do them later. SAQ answers and comments are at the end of the text.

At the end of each Unit text there is an index listing the main terms, which will help you find your way around the text.

TELEVISION PROGRAMMES

An essential part of each Unit is the television programme. Each programme is broadcast twice a week, and lasts about 25 minutes. Most have accompanying notes which you will find in the associated text. Dates and times of the programmes are shown on the Study Calendar.

Three programmes that are not directly linked to a Unit are shown during the year. The first programme of the Course is a voyage of discovery that aims to provide an interesting and exciting perspective on some of the science you will be studying. Later in the year, there is a programme about

Summer School that follows some students through the laboratory sessions, tutorials and free time. Finally, at the end of the Course there is a programme dealing with problems involved in the disposal of nuclear waste. This programme will use many of the ideas and concepts that you have met in the Course.

Many students find it useful to videotape programmes for later use. At Summer School, you will be able to see any programme you missed and even preview future ones! Your Regional Centre also has copies of all S102 programmes, which are available for viewing.

AUDIOVISUAL (AV) SEQUENCES

Certain topics are taught through an AV sequence. The audio part of these sequences is on the cassettes that you are sent with the other Course materials. The visual component may be a series of diagrams and descriptions set out as frames in the relevant Section of the text, or it may be colour photographs, geological samples, 3-D slides or models that you construct. AV sequences are designed to help you understand the more difficult topics, introduce practical work or provide you with examples to work through. In doing this type of work through AV sequences, you can study at your own pace and repeat the sequences to reinforce your understanding as often as you wish.

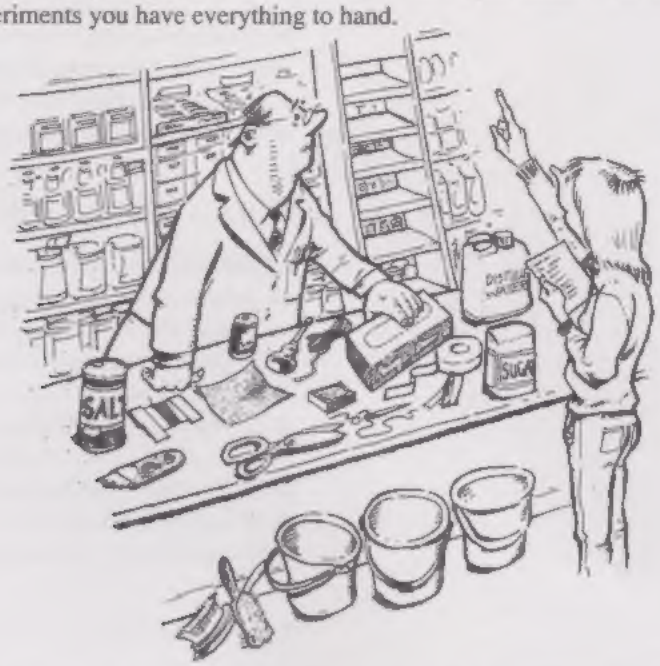
EXPERIMENTS

Practical work is a very important aspect of science and of this Course. About half of the Units have experimental components, and each experiment is closely integrated with the other material in the text. Most of the equipment that you will need is sent to you as a Kit in two parts. At the end of January, the first part will arrive via parcel post; it contains the materials for Units 1 to 12. In April, after final registration, the second part will be despatched (by a road carrier); it contains the apparatus and chemicals for the experimental work of the remaining Units. A short booklet in each part of the Kit shows the layout of the apparatus and how to set up certain pieces of equipment, such as the weighing balance. Important information regarding the use and safety of the chemicals is also included in the booklet with the second part of the Kit, and you should have this to hand when you come to do experiments involving chemicals.

Clear a suitable space before they deliver your Kit.

The two parts of the Kit fit together in a box, which is about half the size of a tea-chest. You will need to have easy access to the Kit, but store it away from young children as it contains chemicals and delicate glassware

Before you do any experimental work, clear a work-surface (perhaps in your kitchen), and for experiments involving chemicals ensure there is good ventilation. For some experiments you will need to buy or obtain additional items, which are listed in Section 4. *We strongly advise you to collect them now, before you start the Course*, so when you come to do the experiments you have everything to hand.



In the relevant Sections of the text, you will find instructions on how to do each experiment. The apparatus for the experiment is listed under two headings: NON-KIT ITEMS (which you need to supply) and KIT ITEMS (supplied). There is also an indication of the time needed to do the work. It is important that you keep an accurate and complete record of all your experimental work in a special Notebook; you may be asked to write up your experimental procedure or submit your results and interpretation of them as part of an assignment. In Section 4, we provide details of the type of Notebook you need to buy.

COMPUTER-ASSISTED LEARNING (CAL)

To help you understand and revise some topics in chemistry, there are three CAL programmes. You can purchase a disk containing these programs to use on an IBM compatible computer. If you do not have access to a suitable computer, the programs will be available for you to use at Summer School. You will receive further details on how and where you can purchase the disks later in the Course.

3.3 OTHER COURSE MATERIALS

In addition to the Units there are a number of important items that you will refer to throughout the year:

STUDY CALENDAR

This tells you the dates and times of television programmes for the Course, and the cut-off dates for submission of the assignments that constitute the continuous assessment material. You will probably need to refer frequently to this calendar.

ASSIGNMENT BOOKLETS

In each Course mailing there will be an Assignment Booklet containing the tutor-marked assignments (TMAs) and computer-marked assignments (CMAs) relevant to the enclosed Units. On the front page of the assignment booklet is a Table listing the cut-off dates for each assignment. These dates are also given on the Study Calendar, but it is a good idea to mark them in your diary so that you can plan your work to meet these deadlines. Section 7 gives help and advice on starting work on assignments.

STUDY COMMENTS

For each binding of S102 Units you will receive a card containing Study Comments. Study Comments are provided for each Unit of the Course and are designed to help you sort out the 'wood from the trees' as you study the text. They will give you advice on the Sections you need to spend some time on and others that can be read more quickly. You can use the card as a bookmark as you work through the text.

COURSE INDEX

At the end of each Unit text there is an index listing terms with their page references. Often you will need to refer back to topics and concepts, and the index will enable you to locate terms quickly. The Course Index, enclosed in this mailing, is a compilation of all the Unit indexes and thus covers all the Unit texts.

GLOSSARY

The Glossary is a compilation of important ('flagged') terms from each Unit, except Unit 26. Glossary entries give the meaning of these terms, and refer you to the relevant Units. Since the Course covers a number of disciplines, each with its own terminology, the Glossary can be used as a reference document as well as for revision. You may also find it helpful when answering assignment questions.

REVISION GUIDE

In the last Course mailing you will receive the Revision Guide and a Specimen Examination Paper. The Revision Guide contains material to help you in your exam preparation; for example, it lists the main concepts that you are required to know. You will receive a tape sequence to help you with revision.

3.4 SUMMER SCHOOL

The week you spend at Summer School is a very important one in your progress through the Course. S102 Summer Schools take place at the universities of Reading, Keele and Heriot Watt from July to September. In your Summer School week, you will carry out practical work in laboratories and go on an Earth sciences field trip. You will have the chance to attend tutorials and lectures on topics related to the Units, and be able to discuss ideas and problems with fellow students and tutors. Work is intense, but students generally find that the week gives a tremendous boost to their studies. Many academic problems can be solved quickly and easily in this environment, and interesting ideas can be explored by discussion with others. You will be given some choice about location and date.

3.5 THE STUDY CENTRE

'No, of course it's not inconvenient'

At the beginning of the academic year, you will receive a mailing from your Regional Centre giving information about your Study Centre, the name of your tutor counsellor and discipline tutors. The dates and times of Study Centre sessions will be sent either direct from your Regional Centre or through your tutor counsellor. Tutorial sessions will be held at regular intervals and we advise you to attend. Your tutor counsellor will probably not be a specialist in all four disciplines of the Course, and so you will also have one or more discipline tutors who will give tutorial sessions at the Study Centre. These tutorials will be related to the subject matter of just one discipline of the Course. The tutor counsellor and discipline tutors work together as a team to help you with your understanding of the science concepts and development of skills. Your tutor counsellor will also be available to help you throughout the year, with both study and administrative problems. If you have any personal problems (and we all have *them*!) that affect your studies, or if you are running behind with the Course, you should not hesitate to contact your tutor counsellor, who will advise you.

When you visit your Study Centre, you will find out what facilities are available there; for instance, you may have access to a library. Study Centre meetings are optional, but most students find them enjoyable and helpful, and they provide the opportunity to meet and get to know other students doing the Course. Students sometimes form a self-help study group, which meets at other times by mutual arrangement, and many find this kind of informal meeting extremely beneficial. If you cannot attend tutorials but would like to join a self-help group or just chat to another student on the telephone, contact your tutor counsellor who should be able to put you in touch with other students in your area.

A tutorial may take the form of an informal meeting, or it may concentrate on specific difficulties encountered by students. There will always be help and discussion available for any academic queries you may have. Study Centre meetings can also be a tremendous help in times of difficulty—when you discover everyone else is having problems with the same Section of the Course! Discussion of assignment questions with fellow students and your tutor is often valuable and it forms an important part of your Study Centre work. But do remember that you will gain most by completing the assignment independently. During the year, there will also be counselling

sessions in which help with studying, the choice of future courses, and revision and examination techniques may be among the topics discussed.

4 ITEMS THAT YOU NEED TO PROVIDE

Before starting on the year's study there are certain items you should collect and keep with your other Course materials.

NOTEBOOK

For all your experimental work it is essential to keep a permanent record of your observations and results because you will normally need to refer back to them, perhaps to make a calculation or to answer associated assessment questions. You need to purchase a Notebook for this, ideally about the size of a paperback book and with about 100 pages.

It's all right, it's only the toast!'

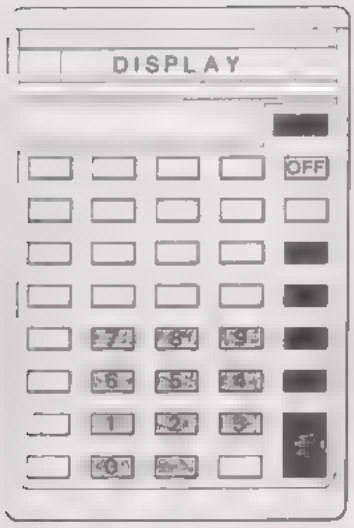


FIGURE 1 All calculators have the functions shown. For S102, a calculator must be capable of performing the following operations: square roots, $\log_{10}$ and inverse, and trigonometric functions—sin, cos, tan and their inverses.

AUDIOCASSETTE PLAYER

You will need this to listen to the cassette components of the AV sequences. AV sequences are integral with the text of some Units (see Section 3.2).

CALCULATOR

We shall assume that you have a calculator of the 'scientific' type and that you know how to use it (Figure 1). It must be capable of evaluating logarithms ($\log_{10}$ and its inverse), square roots, and trigonometric functions (sin, cos, tan) and their inverses. Many scientific calculators also have the following functions, which you will find useful but not essential for the Course: reciprocal of any number ($1/x$), raising a number to a power (x^2, x^y), pi(π), raising the number 10 to any power (10^x), log to base e ($\log_e$), memory, store and recall.

EXTRA ITEMS FOR EXPERIMENTS

In order to do the experiments, you will need a few items that are not supplied in the Kit (Figure 2). You may have to buy some of these items.

We strongly advise you to obtain them now so you have everything you need when you come to do an experiment.

Non-kit items (LISTED IN THE ORDER IN WHICH YOU WILL NEED THEM):

drawing equipment (pencil, ruler, pair of compasses)

thin string—about 3 m
small, heavy objects e.g. two bunches of keys
watch with second-timing facility, or stop watch
dowelling—at least 1.2 m long (a broom handle would do nicely)
tape measure or rule—at least 1.5 m long
Blu-Tack or plasticine

protractor

base of a table lamp or desk lamp
clear glass, single-wire-filament light bulb (e.g. a 25 W candle bulb)

thin card—about 10 cm × 10 cm

distilled water—2 litres (from a chemist or garage; this will be enough for all the experiments)
gas cylinder (Primus 2202 CTC-SP 826 butane cylinder with self-sealing safety valve; **not** Camping Gaz; it is most important that you obtain this type of gas cylinder, so start looking for a supplier now)
matches
paper tissues
scissors
small piece of sandpaper or emery paper
household rubber gloves
Sellotape
9-volt battery (PP7)
metal table knife
a little table salt
a little sugar
small screwdriver

mirror—about 12 cm × 12 cm in area (but it doesn't have to be square)

a little starch (e.g. arrowroot)

large (darning) needle

holly leaves (don't collect now; details follow in Unit 25)
plastic bag and sealing tag

fuse wire, strong cotton or netting

FIGURE 2 Extra items for experiments.

BOOKS AND ARTICLES

During the year, you may wish to do some extra reading on topics related to Course material. This is *entirely optional* (there are no set books for the Course), but if you have time you will probably find it interesting to read around topics covered in the Course. Your scientific knowledge and understanding will benefit, and you will learn of various scientific applications. Often there are articles on scientific topics in the 'quality' newspapers, and magazines such as *New Scientist* will keep you up to date with scientific thinking. Your local library will have books on general scientific topics and some Units provide reading lists.

5 ASSESSMENT

The Course is assessed by a combination of continuous assessment and an examination at the end of the Course in October. Continuous assessment is based on two sorts of assignments: tutor-marked assignments (TMAs) and computer-marked assignments (CMAs). These are contained in three Assignment Booklets, one per Course mailing (see Section 3.3).

The combined system of assessment has been designed to help you derive as much benefit as possible from the Course. Also it gives both you and us a fair and reliable method of collecting information on your progress. The system encourages you to work through the Course at a steady pace and it affords some protection against the effects of ill health or anxiety on the day of the examination.

How does the assessment system work? We start with the continuous assessment.

5.1 CONTINUOUS ASSESSMENT

For TMAs you should submit your written work to your tutor for comments and grading. CMAs comprise multiple-choice questions, in which you have to select the best answer(s) from a set of possible choices. These questions will be marked by computer at Walton Hall and you will be notified of your grade and given some feedback on the assignment.

There are eight TMAs and nine CMAs and you should do your best to submit them all, as they all count towards your continuous assessment mark. Most Units are assessed by both TMA and CMA questions, but a few are assessed by only one of these two forms of assessment (Table 4). The continuous assessment mark will count for 50% of your overall Course score, and the final examination for the other 50% (Table 5). Of the 50% that you can obtain from your TMAs and CMAs, the eight TMAs can give you a maximum of 33% and the nine CMAs a maximum of 17%. All TMAs are weighted equally and all CMAs are weighted equally. Assignment cut-off dates (i.e. the dates by which the assignments should reach your tutor or Walton Hall) are listed on the Study Calendar as well as on the front cover of the relevant Assignment Booklet.

TABLE 4 How the eight TMAs and nine CMAs relate to the 32 Units in the Course

TMA number	Units covered	Discipline covered	Units covered	CMA number
01	2 to 4	general science and physics	1 to 3	41
02	5 to 8	Earth sciences	5–6	42
03	9 and 10	physics	9 and 10	43
04	11 to 14	chemistry	11 to 14	44
05	15 to 18	chemistry	15 to 18	45
06	19 to 22	biology	19 to 21	46
07	23 to 25	biology	22 to 25	47
08	27 to 29	Earth sciences	27 to 29	48
		physics	30 to 32	49

TABLE 5 Allocation of marks

	Percentage of total score
Final examination	50
8 TMAs	33
9 CMAs	17

Units 4 and 26 are not assessed directly during their assigned study weeks. Use these weeks, and the 'break weeks' after Units 18 and 29, to complete the assignments and to catch up on your studies if you are behind.

5.2 THE SUBSTITUTION RULE

We realize that you may occasionally be prevented by ill health or by some other circumstances beyond your control from submitting a particular assignment in time for it to count. Or you may be forced by similar circumstances to do it hurriedly and therefore not do justice to your understanding of the material being tested. To make some allowance for these circumstances, the University operates a *substitution procedure*, which works in the following way:

1 Any assignment that is not submitted counts as zero towards your total.

2 Your *substitution score* will be calculated from your TMA and CMA scores, including any zeros, and your final examination score.

3 This substitution score will then be compared with the scores on each of the TMAs and CMAs, expressed as percentages of the maximum possible score for that TMA or CMA. If any TMA or CMA score is lower, as a percentage, than your substitution score, then that TMA or CMA score will be substituted by the substitution score subject to the following restrictions:

(i) that not more than two TMAs and not more than four CMAs are thus substituted,

(ii) that not more than *one* substitution is made in any one of the four *groups of TMAs* specified below (Table 6);

(iii) that not more than *one* substitution is made in any one of the four *groups of CMAs* specified below (Table 6);

(iv) that substitutions are made for the TMAs and CMAs with the *lowest* scores (this gives you the maximum possible benefit from the substitution procedure).

4 Your overall continuous assessment score will then be re-calculated using the *substituted* scores instead of the TMA or CMA scores they have replaced.

TABLE 6 TMA groups and CMA groups

TMA groups	Discipline	CMA groups
01 and 03	physics and general science	41, 43 and 49
02 and 08	Earth sciences	42 and 48
04 and 05	chemistry	44 and 45
06 and 07	biology	46 and 47

The main point to remember is that *you should submit an assignment if you possibly can, even if it is not your best work.* If you get only 20% for a TMA or CMA, your substitution score will be higher than if you had not submitted the assignment at all. Submission of the assignment also ensures that you receive some correspondence tuition from your tutor or the computer!

A final point about assignments: to score any marks on a CMA, *you must submit it by the cut-off date*—lateness *for any reason* leads to a zero score. If you are concerned your CMA may not arrive by the cut-off date even though it was posted before this date, obtain a certificate of postage that states the posting date. If necessary, you can then demonstrate that the assignment was sent before the cut-off date. You should always aim to get your TMA to your tutor by the cut-off date, but *if you know it will be late, contact your tutor* in advance *to gain his or her agreement for late submission.* The procedure to be followed is set out in detail in the *Student Handbook.*

'Finished that assignment yet?'

You may be wondering whether a group of students should discuss assignment questions before sending them in to be marked. This is not only acceptable but also desirable, and it is not cheating. However, you must finalize your answers on your own and write out your TMA *in your own words*. Under no circumstances should you prepare answers together or copy another student's answers. That *would* be cheating! We do not, of course, expect you to work on your assignments under 'examination conditions'. You are free to refer to the Units and to ask your tutor or tutor counsellor to explain points you find difficult.

5.3 THE EXAMINATION

The examination at the end of the Course is solely computer marked and is divided into two parts, A and B. Part A contains more straightforward questions and Part B contains sixteen more demanding questions, four in each discipline. Later in the year you will receive a Specimen Examination Paper, which shows you the structure of the paper and the types of question to expect. To help you in your preparation for the examination we shall provide you with a Revision Guide and tape sequence.

6 GETTING STARTED

Studying is normally hard work but you can make it much easier by planning your study time. A few minutes of careful planning can save hours of wasted time. In this Section we offer some suggestions on how to plan your work and organize your time.

6.1 ORGANIZING COURSE MATERIAL

One thing you can do now to organize your Course material is create a filing system (Table 7). Remember, the amount of material you receive will increase rapidly, and it is essential that you are able to locate each item easily. If you're not careful, you will quickly be swamped with paperwork!

A system of box files may be convenient for you, as the boxes stack easily and hold lots of paper and booklets. Your first mailing will include several types of printed material that you will receive regularly throughout the Course—contents checklist, stop presses, errata sheets (even we make mistakes!)—as well as texts. First, always check against the contents checklist to ensure you have all the items listed. Then transfer the information from the stop press and errata sheet to the appropriate places. For example, you may need to make a correction on an assignment question or alter the time of a TV programme on the Study Calendar.

When you have set up your filing system, it's easy to sort each mailing as you receive it. Try to pin up the Study Calendar so you have easy access to the TV schedule and the all-important cut-off dates for the assignments. This will help you start to organize your study time.

TABLE 7 A suggested filing system for material received

Administrative material	Course material
Student Handbook	Kit booklets
material from Regional Centre	notes from tutor counsellor, tutor
material from OUSA	contents checklists
Summer School information	stop presses
conditional registration information	errata sheets
	Unit texts
	notes from tutorials/study notes
	assignment booklets
	TMA and CMA feedback

6.2 ORGANIZING STUDY TIME

If you have been working through *Into Science* you may well have set aside time for regular study. When the Course has started properly, you will find it even more useful to allocate regular study time, as the workload will increase considerably. The Course Team has tried to ensure that one Unit (a week's study) will take *on average* 12 hours including assessment. This figure is only a guide, as there is no such thing as an average student. If you have not done any studying for some time it may take you longer than this to complete a Unit. However, if after a few weeks you are taking considerably more than 12 hours to complete your work, try to discuss this with your tutor counsellor and consider your work pattern. Perhaps you can decrease your study time by approaching the work in a different way.

You will, no doubt, have many other things to do during a week but try to allocate yourself set times for your studies and keep to them. It may help to draw up a timetable to cope with all the work you will be expected to do during the year. Mark the dates when assignments are due, and the times and dates of the Study Centre sessions.

Before you start on a week's work, read the Study Guide of the Unit to see if you need to assign time for experimental work; plan when you will be working through the text and watching the TV programme; and allow yourself plenty of time for the assignment questions.

Think now about how you intend to work through the text. When we read or study many of us find it difficult to summarize and pick out the important ideas. This is especially difficult if you are studying a subject for the first time. Study Comments are designed to help you sort out the 'wood from the trees'. For each Unit of S102 (except Unit 26) the Study Comments guide you through the text, pointing out the Sections to which you need to pay particular attention. This may be because you will need those ideas or skills again during the Course or because they are basic, fundamental ideas that you need to understand as a student of science. You will also find references to material that can be read through quite quickly without you needing to remember every detail. Think of this as 'background' material.

We suggest that you use the Study Comments as a bookmark as you work through a Unit so that you can refer to the appropriate Section as you come to study it. However, we also advise that you read through the Study Comments quickly *before* you begin to study the Unit.

As you come to work through the text you may find it useful to highlight important terms and concepts. It is also a good idea to add your own notes in the margin. This ensures you have all your work in one book, making it easier to refer back when doing assignments and revision.

There is some evidence to suggest that when learning on your own, it is better to organize your time in periods of roughly 30 minutes. So if you have set aside about two hours for study, breaking it up into four half-hour periods with a few minutes' break between each is an efficient way of working. After your break, review briefly (say by reciting to yourself) what you have learnt. This approach should help you 'learn to study'. It need not take up a great deal of extra time, but should help you to use your time more effectively.

Tutorials and self-help study groups will allow you to discuss what you have learned with someone else. Discussion of topics and working through problems will clarify ideas and concepts, help your understanding and enable you to learn and remember.

Table 8 summarizes some things to do *now*.

TABLE 8 Things to do NOW

Things to do NOW	
THINK	• where you intend to study • how you intend to organize your Course material
CHECK	• contents checklist • stop press • errata sheet
ORGANIZE	• mailing • study time for week 0 • how you will study • shopping list for Kit items
START	• reading Study Guide to Unit 1 • studying Unit 1

7 LEARNING SCIENCE AND DEVELOPING SKILLS THROUGH S102

In this Section we consider some ideas about studying science and the different skills that are developed during the Course. Becoming more aware of the skills you develop and the way you go about studying and learning will allow you to monitor and improve your own performance, and you will be able to adapt your approach and style of learning to suit the task in hand. If you have studied *Into Science* you will already have been introduced to these ideas—so take this opportunity to think about how you studied and any changes you want to make.

As you study S102 you will be involved in many different activities—all of which will contribute to learning. You will read facts and information, do experiments and gather your own data, and tell friends and tutors what you know and understand. So, we can look at all these activities in terms of science knowledge, skills needed to do science and more general skills that we use all the time as we study.

We will look first at the more general study skills which are useful in a wide range of contexts and contribute to successful performance. As you become involved in doing science you will be using other skills such as observing, measuring and predicting. These specific science skills enable you to be involved in the *process* of science. Put together, study skills and science skills help you to learn and understand the facts and information, that is, you will become knowledgeable about science. You can probably already appreciate how difficult it is to separate these elements clearly when you are involved in learning; however, so that we can consider each element more fully we will look at them separately.

7.1 STARTING WORK ON ASSIGNMENTS

As you progress through the Course you will want to practise using your skills and knowledge. Assignments will help you to do this as well as think about and reflect on your progress at each stage.

At the beginning of each TMA a short section will list the skills you will be using as you answer the questions and the comments you receive back from your tutor should help you critically reflect on your progress. Skills can be developed at different levels and you will find the tasks becoming more complex as you move through the Course.

You will probably have only a limited amount of time to spend on the Course, so it is very important that you use this time as efficiently as you can. One way you can achieve this is by developing study skills—these are universally applicable, rather than subject-specific, and can benefit you enormously. The assignments are designed both to reinforce your understanding of the Course material and to provide you with opportunities to develop and practise these skills.

We will first look at how you might begin to tackle assignments—specifically TMAs. First, it may be useful to think about *when* and *how* you should start working on the assignments.

Have a look at Assignment Booklet 1 enclosed with this mailing. It contains the assignments for Units 1 to 10—three CMAs and three TMAs arranged in order of cut-off date. Take a few minutes to think when it would be most useful to (a) read through CMA 41 and TMA 01 and (b) complete CMA 41 and TMA 01. It is useful to read through the assignment questions *before* you begin to study the Unit in depth. This 'initial read technique' is especially useful for TMA questions because it gives you an indication of the focus of each question.

At the beginning of CMA 41, Part A provides some questions that do not count towards your score. These are formative questions and are designed to enable you to practise completing CMA-type questions and for you to assess your understanding of some of the concepts introduced in the Units covered by the CMA. Answers and comments to these questions are printed at the end of the Assignment Booklet. There will be a similar set of formative questions at the beginning of each CMA, with answers and comments at the end of the booklet. Formative questions are numbered differently to the questions in the rest of the CMA. Do remember not to include the answers to these questions on the CMA form that you send in to Walton Hall. The rest of CMA 41 is divided into different Parts, relating to Units 1 to 3.

When is the best time to complete the questions that relate to Unit 1? The answer, obviously, is straight after you have studied Unit 1, yet you may well find it difficult to put this advice into practice. Many students are tempted to leave their assignments until the last minute, just before the cut-off-date. Try to avoid this—it is far better to organize your time so that when you have studied a Unit you are able to go on to complete the associated assignment questions (both CMA and TMA questions). If you find you are short of time, you will find it beneficial to write notes relating to questions after studying the appropriate Unit. You can then complete the answers or write up the finished version at a later date.

The TMAs in this first Assignment Booklet are presented in a different way to the remainder of the TMAs. In these early TMAs, *what* you have to do, that is the question, is presented in the left-hand column and advice and help with *how* to do it is given in the right-hand column.

When you come to do a TMA question, spend a few minutes reading it *carefully* and thinking about what is wanted and how you will begin to answer it. All questions have a goal—to help you reinforce your understanding of concepts, practice certain skills and sometimes further develop your knowledge. Questions should not be regarded as an opportunity to include everything you know about the topic. To gauge how much detail you should include in an answer, look at the number of marks allocated. A short answer will obviously have fewer marks allocated than a detailed description or complex calculation.

TMAs are returned with a mark and your tutor's comments, and for CMAs you will receive a grade together with answers and comments. Use these

comments constructively and give yourself time to reflect on your progress so that you can use the feedback to move forward in your learning.

Remember, the break weeks give you time to complete the assignments due, and catch up if necessary.

Getting organized is obviously a big part of studying on your own and if you are able to do this from the beginning you will find it easier to 'manage' the work load.

7.2 STUDY SKILLS

This Section provides details of study skills you will find useful when preparing and answering TMA questions. You will already have used these skills if you have been able to study *Into Science*.

Certain study skills, for example, how to write up an experiment report (you will be doing this for TMA 01) are dealt with in the Units. These notes concentrate on *four* other key study skills.

USING SUPPLEMENTARY COURSE MATERIAL

In the same mailing as this Introduction and Study Guide you will find the Glossary and Course Index. You should use the Glossary when you need to check the meanings of terms. The Course Index will enable you to locate the Unit(s) and page number(s) where terms and concepts are explained. Make sure you *always* have these booklets to hand and use them to look up the meanings of any terms you are not sure of when doing assignments or when studying later Units.

ANSWERING QUESTIONS INVOLVING MATHEMATICS AND GRAPH DRAWING

Many students lack confidence to do and understand mathematics, often because they have not 'used' maths for some time. However, certain areas of science use mathematics as a 'tool' to help us in our understanding of phenomena and so it is important that you gain some understanding and appreciation of basic mathematics. Mathematics provides us with 'rules' and a language to help us to explain things. For example, we probably all have a picture of what we mean by the word 'area'. What mathematics does is help us to define precisely the meaning of, say, the area of a rectangle (length $\times$ breadth), and gives us a method to work out a specific area. Thus to make sense of our data and results we frequently need to use mathematics to justify our interpretations and conclusions.

You will have lots of practice solving problems involving mathematics and the Unit material will explain how you should tackle these problems. Before you set out your answer to any problem involving mathematics think about how you are going to present it. To help you do this, have a look at the following part of a TMA question relating to Unit 3. (If some of the terms used in the question and answer, such as weight and g, are unfamiliar to you at the moment, do not worry. You will understand what they mean after studying Unit 3.)

This question concerns two famous ice-dancers, Jayne and Christopher, practising their skating routines. Use the following data:

mass of Jayne $m_J = 49\,\text{kg}$

mass of Christopher $m_C = 71\,\text{kg}$

magnitude of acceleration due to gravity at the surface of the Earth $g = 9.8\,\text{m s}^{-2}$

(a) What is the magnitude of the combined (total) weight of both skaters? *(4 marks)*

(b) At one stage in the routine, Jayne is being continuously pushed forward, with an acceleration of magnitude $0.30\,\text{m s}^{-2}$. What is the magnitude of the net horizontal force that acts on her? Show all steps in your working. *(4 marks)*

Now look at how you might present the answer.

(a) weight = mass × g

Combined (total) *mass* is $(49 + 71)\,\text{kg} = 120\,\text{kg}$

combined *weight* (magnitude) $= 120\,\text{kg} \times 9.8\,\text{m s}^{-2}$

$= 1.18 \times 10^3\,\text{kg m s}^{-2}$

$1\,\text{kg m s}^{-2} = 1\,\text{N}$ (N represents newtons, the SI unit of force—which is what weight is)

therefore combined weight $= 1.18 \times 10^3\,\text{N}$

$= 1.2 \times 10^3\,\text{N}$

(to 2 significant figures, as in the data).

(b) Force (F), mass (m) and acceleration (a), are related by Newton's second law

$F = ma$

substituting given values: $m = 49\,\text{kg}$; $a = 0.30\,\text{m s}^{-2}$

$F = 49\,\text{kg} \times 0.30\,\text{m s}^{-2}$

$= 14.7\,\text{N}$, which is 15 N to 2 significant figures

If you look at the answer carefully you will see that it is presented clearly, concisely and logically, using the correct units at all stages.

For any work involving a calculation always:

- include *all* the steps leading to the final answer (marks are awarded for these steps as well as for the answer);
- present your answer clearly with clear statements where necessary;
- use SI units in your calculations (see Unit 2, Section 2.2), and show the units at each step;
- quote your results, using an appropriate number of significant figures (see Unit 4, Section 3.5) and using scientific notation (see Unit 2, Section 2.5).
- wherever it is appropriate, estimate and record the uncertainty associated with a result (see Unit 2, Section 3.3 and Unit 4, Section 3.3);

Questions involving calculations are *not* confined to the physics Units of the Course. Whenever you are required to answer questions involving mathematics you should *always* present your answers clearly as in the example above.

In an early TMA question you will be expected to draw a graph from given data and be able to answer questions using your graph. You may already have done some preparatory work on drawing graphs in *Into Science*. There is a lot more help on drawing and using graphs in Units 3 and 4. Do not be tempted to skip the relevant sections of these Units since it is an important skill in which you need to become competent.

If you are asked to draw a graph as part of a TMA question it must be done by hand. The question, in part, is assessing your skill in drawing the graph and a graph drawn by a computer is not acceptable.

WRITING SCIENTIFIC ACCOUNTS

Many students find the thought of writing an account daunting. To help you develop and master this skill you will be asked, in an early assignment, to write a short paragraph relating to a topic covered in a Unit. Later, you will be asked to write longer accounts that will include a considerable amount of detail from the Unit(s), perhaps explaining or interpreting scientific concepts or experimental results. In this way you will build up your skill and become competent in scientific account writing. Whatever the question, use these notes to help you prepare your answer.

Writing a scientific account will help you to:

- organize your thinking, and, if required, come up with a reasoned point of view on a topic;
- synthesize information and present it in different forms;
- recognize and build on areas in which you are competent, but also recognize areas where your understanding is weak and in which more work is required;
- practise and develop a skill that you can use in future studies, as well as in other situations, e.g. writing business letters.

Writing accounts involves not only recording facts, but using the skill of organization. Marks are awarded not only for the factual content but also for the *order* in which you consider the information, so there must be a logical sequence or a distinct thread of argument. Facts alone do not produce a good account, although they do provide the foundation and framework for an answer.

You should try to follow a definite sequence of work, starting with consideration of the wording of the question and ending with the final version of the account that will be sent to your tutor.

What is expected?

Look at the question carefully and make sure you understand what you are being asked to *do* and what precisely is meant by the key verbs in the question (e.g. to describe, define, analyse or justify). It is *most* important that you understand the differences between such verbs. Many marks can be lost by, say, simply describing when actually the question asks you to 'compare'. A glossary of these key terms is included at the end of this Section. Look carefully to see what guidance you are given in the question. You may be told the factual content that you are expected to include, the type of approach that is required or the way the information should be

presented. If the question contains scientific terms, you will need to define these as part of your answer.

Collecting the facts

You now need to look into the subject matter using the Units. Ask yourself questions like what? when? and how? about the subject. The answers will direct you to the relevant section(s) of the Unit(s). The index will help you to find specific terms. As you read (or re-read) these sections, highlight those portions of text, or diagrams, that you feel are relevant to the answer so that they stand out clearly.

Note down the definitions of any scientific terms used in the question. For example, if the question says: 'Explain how plate tectonics accounts for the three features of a constructive plate margin that you have described...', you would need to define briefly the terms 'plate tectonics' and 'constructive plate margin'. Use the Glossary to help you with such definitions and to check your understanding of other scientific terms.

Remember you are *not* expected to include information from outside the Course, but you may need to refer to information from, say, a TV programme or some practical work that you have completed.

When you have finished your reading, jot down briefly the points you have selected—either in the order in which they occur in the Unit or in the order you think you will present them. Make a note of the pages on which each point occurs so that you can find it again easily. Note that sometimes the same piece of information may occur in more than one context.

Planning the account

Before you start to write your account it is important that you prepare an *outline* or *plan*. To do this remind yourself of the purpose in writing the account. What do you want to get across? Do you need simply to *describe* or are you being asked to *evaluate* or *justify* your statements? Check again on the key verbs in the title. After you have done this, you may need to *select* from the material you have collected. Be ruthless in discarding *any* material that is *not* relevant. But you should make sure you have sufficient material, including perhaps examples or results, to back up your statements. These will give your account meaning and credibility. Do *not* be tempted to include material that is not relevant because this will be 'padding' which may cost you marks.

You are now ready to write down your *plan* which will

- help you to see the account as a whole;
- help you ensure that important material is not left out and that repetition is avoided;
- encourage you to write fluently once you have started;
- most importantly, help you fit the information you have collected into a logical order or line of argument, and bring the information together in a different context.

The structure of a simple three-point plan is an introduction, a middle and an end. You may well have used this type of plan before—the method can be adopted for a wide variety of accounts. For example, a speaker may adopt this structure by beginning with 'This is what I'm going to discuss', then continuing with the main body of the speech and concluding with 'This is what I've said'.

Three-point plan

The *introduction* should include

- a comment on the topic of the account e.g. what do you understand by it and what are the main issues? and
- which aspects will you be dealing with and why? What will be your general approach?

For the *main body* you should

- list the main points you want to include, one for each paragraph. Each paragraph should make a definite point, supported by items of information from your list;
- check that the points follow a logical sequence or reasoned argument;
- jot down examples and illustrations and decide where you will include them;
- find the appropriate point to include your selected diagram(s). Think how you will use them in your account and make sure you refer to them. *A well chosen diagram may save many words of description.*

The *conclusion* should

- sum up your main ideas or arguments;
- offer a firm or tentative conclusion (if requested) and point out any wider implications or future trends.

For a *short account* or a simple description it may not be necessary to include an introduction and conclusion. However, in answering any question of this type you should always consider what is expected and how you are going to collect the facts. You can then plan the structure appropriate to the question asked.

Occasionally you may be asked to present your information in a different form, for example, as a table. Much of the advice given here will stand you in good stead however you present the information. In the case of a table, the ideas and concepts collected would need to be summarized concisely, but you would be involved in similar preparatory stages of thinking about what is expected, collecting the facts from the Units and planning the final answer

Writing your account

You are now ready to start writing your first draft. As you write keep in mind

- what you want to say;
- why you want to say it, and say it simply and directly.

Write in simple English using reasonably short sentences. You do *not* need to use complex, difficult words or phrases. Make sure you use your own words and don't copy sections from the Units. When you have completed this first draft, leave the account for a day or two, if you have time, but do make sure you will be able to meet the cut-off date. When you come back to it, re-read it critically and check that you have included all the points asked for. One way of doing this is by reading it aloud. This will help you to 'hear' how well it flows and if it addresses the points asked for. You may then feel you are ready to prepare the final version, or you may wish to prepare a revised draft. If you are fortunate enough to be able to input your account on a word processor, it is, of course, much easier to revise drafts.

Remember that an account composed of a disordered collection of facts is likely to earn you fewer marks than a well ordered one where the essential points and arguments are clearly made and supported by one or two facts. Check that your word limit is reasonably consistent with the one set. You

will notice that in most TMA questions we give advice on word length for answers. Usually we say '*in about 200 words*...' or something similar. This recommendation means your answer should be around *200 words* in length. If you find you have used many more or many fewer words, have a careful look at the answer to see if you have (a) included irrelevant information, or repeated yourself; or (b) omitted key points. This is not an easy task and even if your word length is quite different from the one we suggest, you may feel that you do not want to make any changes. In marking questions tutors will *not* deduct marks if you exceed the suggested number of words or use many fewer words. However, you *are* likely to lose marks for omitting key points and for including irrelevant information—especially later in the Course. As you progress through the Course, you will find it easier to select information and sort out what is relevant—this is one of the skills you will get lots of practice in!

Presentation

Whether you are going to write your account by hand or type it, spend a few minutes thinking about the presentation before you begin. Always be careful about the appearance of the final version and make sure it is neat and carefully laid out. Remember to leave a wide margin on the page and write only on one side of the paper. This allows plenty of space for your tutor's comments. You can only gain from presenting your work well. When your TMA is returned, read through the tutor's comments for advice, not only on *content* but also on how to improve the structure and presentation of your accounts in future.

DRAWING DIAGRAMS OR SKETCHES

It is often useful to include diagrams in TMA answers, but drawing diagrams is a difficult skill that you may need to practise. If you are planning to use a diagram in an account, ask yourself why it would be useful and what will it show? A diagram is often useful to help explain a difficult concept. For example, when you come to study Units 5–6 you will learn about the Earth's magnetic field. How might you begin to explain to a colleague the 'shape' of this field? An obvious way would be to use a diagram. There are a number of things to remember as you prepare and draw your diagram.

- Plan where it will be placed in your account.
- Decide what it will be used to show. You do *not* need to reproduce a copy of a diagram from the Units. Your diagram must be relevant to your own answer and may show just one or two important features. It may include information from more than one figure in the Unit. Diagrams do not have to be complicated. For example, if you were drawing a sketch map of how to get to your house for a party invitation, you would not include every small detail. You would make your sketch relevant to your guests and just mark and label the main route, your house and give an indication of distances involved.
- Label the important features, give your diagram a title and if necessary, include a key to shading, etc. For some diagrams, sketch maps or sections you may need to give an indication of scale.
- *Always* make your diagram a part of your answer—it shouldn't be 'wallpaper', it should be included for a reason—to add clarity to your answer. You should refer directly to each diagram so that it helps to describe or explain something. Marks are often allocated for diagrams and you will get most credit for a diagram that is relevant and referred to as part of the text.

7.3 DEVELOPING SKILLS OF SCIENTIFIC INQUIRY—PROCESS SKILLS

Learning about and understanding science depends on the development of *concepts* (such as gravity is a force that acts vertically downwards) and this development depends on using skills to investigate, challenge and modify these concepts. These skills are specific to science and are different from the more general study skills described in Section 7.2. For example, how would you investigate whether *your* ideas about gravity were scientifically valid? You may decide to drop different objects from various heights. On the basis of these results you could then change your ideas so that they were consistent with the evidence you collected. The way you may have tackled this problem through investigation represents one of the skills or *processes* of science. These process skills enable you to test your ideas and change your views, to make conclusions and apply them in new situations. Developing understanding and concepts in this way is at the heart of science.

As you progress through the Course you will find that your thinking and communicating becomes more rigorous, more focused, more systematic and more quantitative. If you intend to study science further you will continue to develop these skills and ways of communicating. Even if you go on to study other subjects, many of these skills will be useful.

Each time you get involved in learning and understanding science you will be using one or more of the following *process skills*:

observing—using all the senses (where safe to do so) to discover more about things or situations;

measuring—recognizing the need to measure; and recognizing the variability/reliability of a measurement and the need to repeat and check a measurement.

modelling—attempting to understand new observations with reference to simple objects or situations already known;

hypothesizing—putting forward tentative explanations for sets of observations;

interpreting—explaining the results of an observation or investigation in relation to existing ideas or concepts;

drawing a conclusion—deciding if the interpretation of the observations supports the hypothesis.

Much of the practical work you will be doing will involve many of these skills. However, we cannot learn and understand the whole of science by doing experimental work alone. We need to consider data from other sources, interpret it and make sense of it. But whether we are learning directly through practical work or using other sources, our understanding depends on building scientific concepts which in turn depends on using process skills. Neither is more important than the other; they are interdependent. As our concepts gradually become more sophisticated, so the skills we use need to be refined and extended. Development of both must go hand in hand.

It is worth investing a little time in thinking about this in relation to how we learn. To show you what we mean let's return to our example relating to the concept of gravity. As you come to study a Unit, it is a good idea to take a few minutes to think and jot down what you already know about the ideas and topics it includes. Before you begin working on Unit 3, for example, you might think about what you already know about gravity. Draw yourself a simple sketch to show the effect of gravity on falling objects. As you

work through the Unit the ideas you set down initially may be changed. You are modifying your own ideas so that they are consistent with a wider range of knowledge and experience and with widely accepted scientific views. Learning in this way you begin to take charge or 'ownership' of the knowledge which will enable you to have a fuller understanding of the concepts.

These notes concentrate on process skills that you will use throughout the Course. Thinking about and using both process and study skills should help you to think about and better understand the way you learn. Because these ideas are difficult, it will be useful for you to return to this Section regularly throughout the Course.

PRACTICAL SKILLS

Much of science is a practical activity. This is not just for the sake simply of keeping you busy—practical work should always be carried out with a clear purpose in mind. Before you begin this type of work, you need to be clear about what you are trying to find out. Then, when carrying out your practical work, you should keep a neat record of your observations and results. You will develop these skills mainly through your practical and experimental work at home and in your work at Summer School.

When you are doing experimental work you will usually be told the equipment you need to use and be given instructions on how to use it. Practical skills include setting up the apparatus or preparing the materials for investigation. As you progress through the Course, you will become adept at modifying experiments in order to improve them.

DATA HANDLING, PRESENTATION AND INTERPRETATION

In doing practical work you will be collecting information that should be recorded. Think about the different ways in which this information could be recorded, what might be included as you collect the information and why it is important to record it clearly and fully. You will need to consider the most appropriate way of presenting the information, for example, as a table or a graph. You will also have to look at and present information or data collected by other people. What sense can you make of these data? You may need to attempt to explain your observations in terms of a concept or principle that you have learned. You will also realize that there are often several ways to explain the data collected. In interpreting data you will come to appreciate the tentative nature of scientific conclusions.

With many sets of data you will see how generalizations or patterns can be made, and how predictions can be based on these patterns.

USING SCIENTIFIC MODELS

In attempting to understand new observations we make reference to straightforward objects or situations that are known. This process is called modelling and is introduced in Unit 1. It is an important and useful skill in science and one you will use a great deal.

CLASSIFYING

One way we can attempt to make sense of the wealth of information all around us is by classifying or grouping objects. We frequently begin to do this as we observe—we select relevant observations, note similarities and differences and we compare in order to group. Classifying or grouping

objects helps us to describe patterns and allows us to note the exceptional or unexpected.

APPLYING SCIENTIFIC KNOWLEDGE

As you become more confident in your own knowledge, you will be able to apply it to explain particular phenomena and to make predictions.

In preparing and answering TMA questions you will be practising these skills from an early stage—you will be using your own understanding to solve a different problem or explain other phenomena.

COMMUNICATING

None of the study skills or process skills would be of much use if you were unable to communicate what has been done. We all need to be able to follow instructions that are given verbally, or in written and/or diagrammatic form. We also need to be able to describe or report on work orally, or by using diagrams, or in writing. In doing this we should be able to put the events in the correct sequence and use tables, graphs, models, etc., to represent the information. This means that we have to select appropriate ways of presenting the information.

7.4 SKILLS LISTED IN TMAS

The assessment material is designed to help you with such learning, by giving you an opportunity to practise the various skills mentioned above, while simultaneously reinforcing your understanding of concepts and principles. As you work through the Course, you will be able to see how your own understanding of concepts is developing—ideas that appear to be very difficult at first, often become straightforward after you have been working with them for some time. This is one of the most rewarding aspects of learning.

The study and process skills that will be developed as you answer the questions are listed at the beginning of each TMA. Table 9 lists all the skills developed through TMA questions, although not all will necessarily be part of the assessment material in any one year.

TABLE 9 Skills addressed through TMAs

PRACTICAL SKILLS
Observing
Measuring
Following instructions to set up and carry out practical or experimental work
Evaluating practical work in terms of design, method and accuracy of results obtained
Recognizing and estimating uncertainties in measurements
Planning and designing an experiment to test a hypothesis using knowledge already acquired
DATA HANDLING, PRESENTATION AND INTERPRETATION
Collecting and recording data in an appropriate form
Representing data in an appropriate form using tables, graphs, etc.
Making deductions and interpreting information
MATHEMATICAL SKILLS
Using a calculator of the scientific type

Performing arithmetic operations with integers and fractions
Using the correct scientific notation and the appropriate number of significant figures
Estimating and approximating for checking calculations
Using logarithms and exponents (other than base 10)
Using simple trigonometry (including sin, cos, tan)
Manipulating simple algebraic equations
Using SI units for basic physical quantities
Plotting numerical data (given or collected) in graphical form
Making interpretations from numerical data in a variety of forms

USING SCIENTIFIC MODELS

Using models to visualize and represent information
Using models to explain and predict situations

CLASSIFYING

Sorting according to one/several attributes
Recognizing criteria used for sorting
Devising own criteria and sorting in appropriate ways

APPLYING SCIENTIFIC KNOWLEDGE

Applying knowledge to explain a particular phenomenon
Applying knowledge to make predictions
Making generalizations and deducing from general principles

COMMUNICATING

Identifying relevant (from irrelevant) information and presenting it in scientific language (including symbols)
Using tables, graphs, models, etc., to represent information
Comparing and contrasting information and/or data
Presenting a written report of an experiment
Presenting information in a structured and logical way as a scientific account
Analysing and interpreting information from a variety of sources (for example, texts, TV, experiments, data given in assignments)

GLOSSARY OF TERMS USED IN ASSESSMENT QUESTIONS

ANALYSE Break down into its component parts. Examine critically or minutely and show how the parts interrelate.

ASSESS Consider the value or importance of something, paying attention to positive, negative and disputable aspects.

COMPARE Identify the characteristics or qualities that two or more things have in common (but probably pointing out their differences as well).

CONTRAST Point out the differences between two things (but probably identifying their similarities as well).

COMPARE AND CONTRAST Find some points of common ground between *x* and *y* and show *where* and *how* they differ.

DEFINE State the exact meaning of a word or phase. In some cases, it may be necessary or desirable to examine different possible, or often used, definitions.

DESCRIBE Say what a thing looks, sounds, feels like, etc., or spell out the main aspects of an idea or topic or the sequence in which a series of things happened.

DISCUSS Investigate or examine both sides of the issue; sift and debate; give reasons for and against.

DISTINGUISH OR DIFFERENTIATE BETWEEN Look for differences between.

ESTIMATE Give an answer to an accuracy appropriate to the situation.

EXPLAIN Tell how things work or how they came to be the way they are.

EVALUATE Make an appraisal of the worth of something (see ASSESS above).

HOW FAR To what extent; usually involves looking at evidence/arguments for and against and weighing them up.

ILLUSTRATE Make clear and explicit; usually requires the use of a figure or diagram to explain or clarify, or make clear by the use of concrete examples.

INTERPRET Clarify something or EXPLAIN (see above), perhaps indicating how it relates to other things or ways of looking at them.

JUSTIFY Express valid reasons for accepting a particular interpretation or conclusion, probably including the need to argue a case (i.e. make a logically structured case, based on appropriate evidence, for and/or against some given point of view).

LIST Give a comprehensive list. No reasons or explanations are necessary.

OUTLINE Give the main features or general principles of a subject, omitting minor details, possibly setting them within a clear structure or framework to show how they interrelate.

PLOT Draw an accurate graph (to scale) on the basis of plotted points.

SKETCH Show important features of a graph (e.g. shape) or figure; do not worry about scale; do not plot lots of points or include minute details.

STATE Present in a brief, clear form.

SUMMARIZE Give a concise, clear explanation or account of, presenting the chief factors and omitting minor details and examples (cf. OUTLINE).

And so, after all this advice, it's time to begin. Good luck with your studies!

ACKNOWLEDGEMENT

Cartoons Gary Rees

USEFUL GENERAL INFORMATION

Problem/subject	Whom or where to contact
Queries about fees, registration or credit exemption	The Registry, The Open University, P.O. Box 48, Milton Keynes MK7 6AB
Non-receipt of correspondence material	The Manager, Correspondence Services, The Open University, P.O. Box 50, Milton Keynes MK7 6AE
Clarification and/or help on any of the Course material or on CMAs	Your tutor counsellor or your Course tutor (according to their particular specializations and the type of problem)
Queries about non-receipt of grades for CMAs	Assignment Officer, Examination Section, The Open University, Milton Keynes MK7 6AF
Comments and queries about the subject matter of specific TMAs	Your Course tutor for the particular assignment
Comments on the Course itself (e.g. suspected errors, suggested improvements)	S102 Course Manager, Faculty of Science, The Open University, Milton Keynes MK7 6AA
Comments, suggestions, complaints etc. about Study Centre facilities	Your Regional Centre
Queries about non-receipt of Experiment Kit:	
(a) if you have received a despatch advice card	The Open University Warehouse, Denington Industrial Estate, Wellingborough, Northants NN8 2RF
(b) if you have **not** received a despatch advice card	Undergraduate Fees Office, The Open University, Milton Keynes MK7 6BJ
Queries about items missing from, or damaged in, the Experiment Kit	The Open University Warehouse, Denington Industrial Estate, Wellingborough, Northants NN8 2RF

S102 UNITS

1	Science and the planet Earth	19	Life and evolution
2	Measuring the Solar System	20	Inheritance and cell division
3	Motion under gravity	21	Genes and evolution
4	Practical work in science	22	Biochemistry
5–6	Into the Earth: earthquakes, seismology and the Earth's magnetism	23	Physiology
		24	DNA: molecular aspects of genetics
7–8	Plate tectonics: a revolution in the Earth sciences	25	Ecology
		26	Biology reviewed
9	Energy	27	Earth materials and processes
10	Modelling the behaviour of light	28–29	Geological time and Earth history
11–12	Atomic structure		
13–14	Chemical reactions and the Periodic Table	30	Quantum mechanics: an introduction
15	Chemical equilibrium	31	Quantum mechanics: atoms and nuclei
16	Chemical energetics		
17–18	The chemistry of carbon compounds	32	The search for fundamental particles